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THE JOURNAL OF INDUSTRIAL HYGIENE

AND ABSTRACT OF THE LITERATURE

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Physical Examinations with Follow-Up Work in a Department Store

Essential Factors in the Recording of Cases of Skin Diseases Due to Occupation

Some Observations on Industrial Lighting

The Future of the Child Labor Question

Action of Irritant Gases upon the Respiratory Tract

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THE JOURNAL OF INDUSTRIAL HYGIENE

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PHYSICAL EXAMINATIONS WITH FOLLOW-UP WORK IN A DEPARTMENT STORE*

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and

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THE economic waste in industry due to absence from work and to labor turnover is caused largely by avoidable illness and physical disability. This waste is so great that many employers have instituted physical examinations for prospective employees in an attempt to lessen it. These examinations perform several functions:

1. They enable the examiner to discover physical defects and to advise new employees with regard to their correction. By following up individual cases the examiner is able to persuade many persons to improve their physical condition, thereby increasing their chances for promotion.

2. They exclude from employment those who have contagious diseases and those who are in such physical condition that they are likely to be unable to fill their positions satisfactorily and to become a liability rather than an asset.

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3. They make possible satisfactory placement of many persons who are handicapped physically and are unable to perform some types of work.

In a great many manufacturing plants, physical examinations of new employees have been used for years. The surprising fact that department stores, banks, offices, and similar organized groups have used them very little makes information concerning examinations in such organizations scarce, and prompts us to present some of the findings in such examinations in a department store during the year 1922.

EXAMINATIONS

The physical examination of prospective employees should be sufficiently thorough to establish either the existence of defects which may cause disability or inefficiency, or the good health of the individual examined. Superficial ex-

aminations give a false sense of security or are resented as unprofessional and worthless. Since the examination is routine in character, however, it should not consume so much time that it becomes an unjustifiable expense.

loosened or removed sufficiently to allow examination of the heart and lungs; only the upper part of the chest is examined. The presence of a trained nurse is essential in all examinations of women unless the physician is a woman.

Form 715 B

FIGURE 1

Front of Physical Examination Card

The Halle Bros. Co.

PHYSICAL EXAMINATION

Examination Date.....

Name..... Age.....

Dept. ..... M. S. W. D.

Address..... Tel. No.....

Previous illness: Diphtheria, Scarlet fever, Pneumonia, Typhoid, Malaria, Rheumatism, Tonsilitis

Bad cough..... Tbc. in family..... Accidents.....

Appetite..... Bowels..... Urination..... Menses..... Fainting..... Vaccination.....

Special note regarding abnormalities.....

.....

Physical condition:

Recommendations made to applicant.....

.....

The completeness of the physical examinations necessarily varies somewhat with men and women. In all cases, there is a brief personal and family history, a record of the weight and height, and a test of vision (with and without glasses, if worn). This part of the examination is made by the nurse. The physician examines the ears, nose, throat, and teeth, looks for goiter, enlarged cervical glands, and pediculosis or skin diseases, and notes the general development and posture and the cases of flatfoot. When women are examined, the clothing is Men are stripped to the waist. The chest is examined anteriorly and posteriorly, the abdomen is palpated, and an examination for hernia and venereal diseases is made. In the case of both men and women, urine is tested for albumin and sugar, and a microscopic examination is made if albumin is found. The record form used is shown in Figures 1 and 2.

The time required for the examination which we make varies considerably, but does not average over fifteen minutes. When a serious defect is found, more

time may be necessary and full explanation of the significance of the condition and advice as to its remedy should always be given. We have had patients, even when rejected from employment, express much gratitude for the information given. In conducting the examination, tact and a reasonable consideration for the individual's sense of modesty will win gratitude and confidence.

After this routine examination each person is graded according to his or her physical condition, and the rating is reported to the employment department. This physical rating forms part of the employee's record in the superintendent's office and is taken into consideration in making transfers and promotions.

Table 1 gives the physical rating in the 1,397 examinations which we made during the year 1922. Of these examinations 893 were of women and 504 were of men. It will be seen from this table that only 405 applicants, or 29 per cent. of the total number of persons examined, were found to have no defects. This gives some idea of the field for advice and for following up individual cases for the correction of defects.

FIGURE 2

Back of Physical Examination Card

Physical Examination: T. ..... P. ..... Weight..... Height..... General appearance.....

Nutrition..... Development..... Skin & Scalp.....

Vision: R. ..... L. ..... Color sense..... Hearing: R. ..... L. .....

Pupils..... Tonsils..... Teeth.....

Lungs..... Heart..... Abdomen.....

Extremities..... Hernia .....

Reflexes..... Urine Ex. Alb. ..... Sugar.....

Glands..... Goiter..... Blood Pressure..... Feet.....

.....

.....

.....

.....

.....

Attitude of Applicants toward Physical Examinations

In the course of four years of required physical examinations of applicants for this store we have encountered not more than a dozen refusals to be examined. These refusals were, we believe, due to apprehension of the discovery of defects already known to the individuals which made them anticipate rejection. We consider them, therefore, a probable saving to the store rather than a loss.

TABLE 1.—PHYSICAL RATING OF APPLICANTS

Average store population, 1,458

	Rating	Number Examined M.	F.	Total
A+[1]	Exceptionally good physical condition	7	7	14
A [2]	Average good health; no defects	151	240	391
B+	Slight defects	141	341	482
B	Minor defects; more serious	149	259	408
C+	Serious defects; correctable	29	17	46
C	Permanent defects	17	20	37
D+	Disabling defects; rejection advised	9	7	16
D	Communicable diseases; unconditional rejection	1	2	3
	Total	504	893	1,397

[1]Includes individuals who have no defects and who in addition show indication of physical vigor and fitness.

[2]Includes individuals who have no defects, those who have defects which have already been corrected (such as defective vision with glasses which make good correction), and those who have teeth missing but not enough to prevent satisfactory mastication.

Rejections

The question of rejections (D+ and D) in physical examinations is one of great importance. We feel that rejections should be as few as possible, and that an effort should be made to use those who are physically handicapped, provided there are positions available which they can fill satisfactorily. A near-sighted policy of picking out only those who are in the best physical condition and rejecting all others would be an injustice to many who can do certain types of work satisfactorily, even though they are not in the best physical condition.

The question of rejections can be solved satisfactorily only by close cooperation between the employment department and the medical department. Unconditional rejection (Class D) should be made only in the case of persons having contagious diseases. We have been in the habit of discussing each case of serious disability with the employment manager. Whether an applicant is accepted or rejected may depend on other factors than his physical condition. He may have special training or experience that would warrant accepting him in spite of serious physical defects, or a position may be extremely difficult to fill. We have working for us an Armenian rug weaver who mends oriental rugs. He was found at the time of examination to have nephritis. In fact he had just spent some time in a hospital, and there was a possibility of his having to return soon for further treatment. He lost a good deal of time at first, but he is still in our employ. Had his position been easy to fill, he would have been rejected, but under the circumstances the logical thing to do was to accept him.

In our series of 1,397 examinations, there were ninety-nine cases in which the question of the advisability of rejection was taken up with the employment manager. The attitude of the examiner in these cases was not to advise rejection, but to explain the defect and advise how the applicants might safely be accepted. Thirty-seven of these cases (Class C) had permanent defects for which light work only was suitable, but nearly all of them were accepted. The total number of rejections during the year was twenty-nine; the rejection rate, 2.1 per cent.

With a growing realization that physical examinations are a part of sound business methods, more and more employers are adopting them. The time will come when the large majority of workers in every line will be required to have physical examinations before employment. If, therefore, rejections

are made on obscure or inadequate grounds, many workers will find it extremely difficult to obtain employment, and their unemployment will be an economic loss to society.

Defects Encountered

In Table 2 a list is given of defects found in the 1,397 examinations made during 1922. There is, of course, a good deal of overlapping in this table, since many employees showed several different defects. Moreover, the classification is not so accurate as it would have been if a definite system of classification had been adopted before the examinations were made. The table is given principally to show the opportunity that is presented, in connection with these physical examinations, to urge the correction of defects. It will be seen that 2,767 different defects were found in the 1,397 persons examined—an average of two per individual—and that the large majority of these defects were correctable. Included in this table are 445 cases of defective vision in which there was good correction with glasses and 539 cases in which teeth were missing and reconstructive dentistry was needed, though the defects noted did not interfere with mastication. These conditions did not exclude the applicants from Class A.

About two persons in every three had defects of the teeth which were obvious to a medical, not a dental, examiner. Vision was defective in half the persons examined. One person in every three was 15 per cent. over or under weight. One hundred and sixty-seven persons, or 12 per cent. of the total number examined, were suffering from goiter. The commonest group of disabilities—those which caused nearly 40 per cent. of the lost time from absenteeism, as shown

TABLE 2.—PHYSICAL DEFECTS FOUND IN 1,397 EXAMINATIONS DURING 1922

No defects found in 405 applicants (29%)
Average number of defects, per person, 2

1. Vision			701
	Defective vision, with glasses; correction good	445	
	Defective vision, with glasses; correction not good	116	
	Defective vision, no glasses	122	
	Permanently defective vision; uncorrectable	18	
2. Nutrition			528
	More than 15% overweight	192	
	More than 15% underweight	336	
3. Defective hearing		20	20
4. Teeth			887
	Teeth missing and reconstruction needed	539	
	Small cavities	66	
	Carious roots	165	
	Pyorrhea	19	
	Need cleaning	98	
5. Tonsils enlarged and diseased		38	38
6. Goiter		167	167
7. Circulatory			50
	Organic heart disease	8	
	Functional cardiac conditions	11	
	Cardiac irregularities	9	
	Hypertension	22	
8. Lungs			10
	Active tuberculosis	3	
	Chronic bronchitis	7	
9. Hernias		34	34
10. Skin Diseases		93	93
11. Flatfoot			97
	Painful	63	
	Not painful	34	
12. Severe dysmenorrhea		90	90
13. Abnormal urinary findings			52
	Albuminuria without casts	42	
	Albuminuria with casts	4	
	Glycosuria	5	
	Cystitis	1	
			2,767

in a previous study[1] made by this store —is the group of respiratory infections. Our routine physical examinations disclosed only thirty-eight cases of enlarged and diseased tonsils. Immunity from or susceptibility to the common cold can seldom be discovered by such an examination. We look to medical science to develop some simple methods to furnish us with data on this subject, which is so important from the point of view of preventive medicine. Nervous disorders form another group of common complaints leading to lost time and inefficiency to which no clue is given by a routine examination. An unpublished study of foot defects or weaknesses shows that they occur in about one in every three women standing at work. These painful conditions, too, are largely functional disorders and therefore are not easily discoverable in a routine examination. Only ninety-seven, or 7 per cent., of the applicants showed flat feet. They probably represented only the more severe cases. We consider it remarkable that no cases of venereal diseases were found. The examination of women was not complete enough to detect such diseases in the absence of a generalized eruption, but in the men venereal disease showing the usual clinical signs would have been discovered.

One encouraging factor in the health situation is that we have found fewer defects in the younger than in the older generation. Supervision of the health of schoolchildren in Cleveland is accomplishing definite results, and the education of the public in the prevention of disease and in the improvement of the physical condition is making the most progress where it will do the most good —in the younger generation.

As a result of these findings and of four years' experience with physical examinations in this store, we believe that our chief problem is to improve the health and the physical condition of the large number of persons who cannot be rated under Class A. We meet altogether too many people who need this improvement but cannot have it for financial reasons. They are in their present condition because they cannot afford to go to private physicians and dentists and are not willing to accept charity. This situation is a reflection on the effectiveness of both the medical and dental professions. The physician who has the health supervision of a group of employees must attempt to solve this problem in whatever way seems most feasible.

Follow-Up Procedure

The essential for insuring success for all work in the correction of defects and the supervision of health is a thorough follow-up system. The employee with a correctable defect is summoned regularly, once every month or two, in order that the physician may see what progress is being made and solve any problems that may have arisen.

In following up cases of physical defects, we are careful to explain that correction of defects is not as a rule compulsory, but that it is for the employee's own good and that we are anxious to have all employees rated under Class A. There are certain cases, however, especially those of defective vision or bad teeth, in which we feel that the defect is a handicap in the performance of the work, and should be corrected from the standpoint of efficiency. Indifference, in such cases, for a prolonged period warrants bringing pressure to bear from the superintendent's office, and giving notice that the employee will be dis-

[1]Swan, C. A.: Causes of Absenteeism among Store Workers. Nation's Health, 1923, 5, 163.

charged unless he makes an effort to improve his physical condition. These extreme measures should be taken only when indifference is the sole reason for delay, and when follow-up work for two or three months shows no results.

There are, of course, cases of minor defects, where follow-up work for eight or ten months shows no results, and where the defect is not serious enough to warrant bringing pressure to bear on the employee. One should not be too easily discouraged, however. We have often followed cases for six or eight months unsuccessfully, but finally the delinquents took our advice, had their defects corrected, and afterwards thanked us for our interest, saying that if we had not constantly reminded them of the necessity of correcting their defects they would probably have neglected themselves indefinitely.

Physical examinations are the basis of medical supervision in stores and similar organizations, but experience has taught us that such examinations should be only the first step. Their value, as we have already indicated, is lost unless the follow-up system is effective. A store health department should have appropriate equipment and a personnel capable of giving suitable relief and advice in minor complaints. The physician should be in a position to refer cases to clinics when advisable, or to co-operating private physicians or dentists who do good work at reasonable charges. An employee, of course, should be referred to a particular physician or clinic only when he does not have one of his own choice to go to, or when he is not getting satisfactory treatment.

Re-examination

In order to insure continued health, medical supervision requires that everyone be re-examined at regular intervals. In this store such examinations are made free of charge, and are entirely voluntary. Many workers of the permanent staff have already been re-examined. The examinations can easily be made when an employee returns after illness or when he comes to the store health department with a minor complaint, in order to obtain relief and advice. The executives of the store have expressed their approval of and confidence in this procedure by coming up at intervals of less than six months for re-examination. The findings in these examinations are recorded on a blue card which is similar to the form shown in Figures 1 and 2.

Summary

Physical examinations of prospective employees in department stores are desirable because (1) they protect customers and old employees from persons with infectious diseases; (2) they protect the applicant from undertaking work for which he is not adapted physically; and (3) they protect the employer from economic loss by enabling him to place employees in positions for which they are physically fit.

Our findings disclose that of 1,397 persons examined, 405—29 per cent.—had no defects or had minor defects already corrected. The remaining 992 individuals had 1,783 defects, averaging nearly two per person.

Physical examinations are only the first step in preventive medicine in department stores; without an effective follow-up system the value of the examination is, in many cases, lost.

The expense of physical examinations is entirely justified by the results obtained in returns to the store.

ESSENTIAL FACTORS IN THE RECORDING OF CASES OF SKIN DISEASES DUE TO OCCUPATION*

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Introduction

FOR the clarification of our knowledge concerning skin diseases due to occupation it is essential that each individual case be studied carefully with a view to the accumulation of exact information about these diseases. Not only is it necessary to study carefully the types of lesions produced on the skin, the treatment, and the results of treatment, but it is equally important that careful attention be paid to the history of the individual worker, his job, and the substances which he handles. The facts relating to these latter conditions are often not ascertained, or at least are not reported on a great many of our hospital records. The rush of the day's work does not allow us to obtain and preserve the requisite information unless some carefully thought-out, prearranged plan is followed. It is with a view to facilitating the acquisition of desirable data in a more concise and logical manner that I am presenting an outline for making a record of the essential factors in each individual case.

The adoption of such a routine as I suggest in examining cases of skin diseases due to occupation, together with the use of printed or mimeographed forms upon which the results of questions and examination may be recorded, will insure thoroughness and secure data on all factors about which it is essential to obtain information. It will also accelerate the examinations, provide adequate records of their results for the study of groups of cases, and preserve reliable evidence from which to draw conclusions.

It seems reasonable to expect that a careful history, especially with relation to the work which the individual performs, combined with an accurate analysis of the substances used and a clear record of the lesions produced, will give us valuable information for analysis and will certainly aid us in the prevention and treatment of similar cases. An analysis of a large number of such records should yield a better understanding of the effect of various substances on the skin, of the adaptability of certain types of individuals to certain occupations, and of other open questions in this field. It is possible, too, that such a study in conjunction with adequate experimental and laboratory facilities would throw more light on the fundamental causes of the process in the skin.

The study of each case can logically be undertaken under the main divisions of history, work, examination, diagnosis, and treatment.

History

The history of the individual case should include a discussion of previous skin eruptions, a history of the patient's general health in a rough way, and a rather detailed account of the present skin condition. In discussing the previous troubles of the skin it is well to ascertain the types of eruption as far as possible, the dates of their occurrence, and whether or not there was any relation to occupation. The history of pre-

*Received for publication Oct. 19, 1923.

vious skin irritations or skin diseases is often neglected, but I feel that a record of these gives some index of the sensitiveness of the skin and affords, perhaps, a guide in the prognosis and a clue as to the wisdom of returning a patient to his occupation. In this connection it is interesting to note that a recent study by Jaeger (1) indicates that the application of certain substances to the skin of normal individuals and to normal areas of individuals with some form of eczema produces a dermatitis in 51 per cent. of those with eczema, against only 4 per cent. in normal individuals. Furthermore, a history of numerous irritations of the skin would undoubtedly suggest a reason against employing a person in a position where he would come in contact with irritants, and would also furnish an argument against returning him to such a job.

The history of the patient's general health should include details of previous illnesses and symptoms if the skin affection has been of long duration. The history of the present skin condition would naturally include information in regard to its duration, the primary involvement, the areas subsequently involved and the order in which they were affected, and the patient's idea of the appearance at first, particularly regarding redness, vesicles, pustules, fissures, etc., as well as at later periods.

The manner and type of previous treatment should be investigated thoroughly for the reason that the original condition is often intensified or changed by injudicious treatment of one kind or another. An inquiry should be made as to whether the patient has received treatment at home, at the factory, by the local physician, or at the drugstore, and the reaction to the treatment which has been applied should be ascertained. A discussion of the various symptoms which may have appeared should include an inquiry as to itching, burning, pain, crawling, and oozing, and also as to whether they had been severe enough to require giving up work or to disturb sleep.

Work

This should include a statement regarding the nature of the patient's present job and the length of time he was employed at it before his skin became affected. It should also include a record of his previous occupations and their effect upon his skin.

The work of the patient, the substances he handles, and the part he plays in the industrial process call for a most careful questioning. This is often extremely tedious because of the workman's lack of knowledge of details, his inability to understand or talk good English, or his mental equipment. Detailed questioning in regard to this part of the examination is essential in attempting to determine the causal factor. A visit to the industry in question is often of great service in familiarizing the physician with details of the particular process. If the co-operation of the executives of the concern by which the patient is employed can be obtained, an effort should be made to ascertain the exact composition of the substances handled by the worker, or at least to secure, for the purpose of chemical examination, some of the substance suspected as the cause of the skin irritation.

The cleansing process employed by the individual workman in the factory and at home is also a subject about which he should be questioned carefully. It is desirable to know not only the kind of soap he employs but also whether or not he uses other speedy cleansing agents or such agents as gasoline or

benzine. It is essential to inquire whether there have been any recent changes so far as he knows in the work process, in the substances handled, or in the cleansing process which he employs. It is well to ascertain also whether any other individual has been affected.

The question of work outside the regular hours should be investigated for the reason that a jeweller may be using a paint remover on furniture or a clerk may be working on his neighbor's automobile in his spare time.

Examination

The general character of the patient's skin deserves recording. It should be stated whether the skin is blond, brunette, moist, dry or oily, and whether or not it is a thin type of skin. A note as to the general amount of hair should also be made. The work of McConnell (2) among printers has indicated that individuals with dry skin are much more susceptible to dermatitis than individuals with a normal amount of oil in their skin. The study of a large group of cases might perfectly well indicate the relationship of some other character of the skin to certain chemicals used in industry. The location and distribution of the eruption is important—whether it is localized on the hands, arms, face, legs, body, neck; whether it involves the nails; and whether, in general, it involves the exposed surfaces, the flexor or extensor surfaces, or the hairy areas. A record of the types of lesions which are present is essential—whether they are primary lesions (erythema, papules, pustules, etc.), or whether they are secondary (scales, crusts, excoriations, etc.). The character of the eruption as a whole should be studied, and the color, grouping, and amount of infiltration of the lesions should be noted. The mucous membranes should be examined in a general way. Various factors in the case may indicate other examinations, for example, of the glands, tongue, or teeth.

RECORD FORM*

Name ..... Date.....
Address .....
Age .....Nationality... M-- S-- Wid-- ....
Occupation .....
Employer .....

HISTORY:
- Previous skin eruptions .....
- General health .....
- Present skin condition—duration, appearances, etc. .....
- Previous treatment .....
- Symptoms .....

WORK:
- Previous occupations .....
- Present occupation—details—process, substances, cleansing process .....
- Other work .....

EXAMINATION:
- General skin .....
- Eruption—distribution, lesions, character.....
- Mucous membranes, glands, tongue, teeth, etc....
- Evidences of other conditions .....
- Examination of process or substances.....

DIAGNOSIS AND OPINION:
- Dermatosis Industrialis (type of disease, cause or occupation) .....
- Probable....Possible....Not D.I. but.....

TREATMENT:
- Local .....
- General .....
- Preventive .....

*This form, spaced to cover both sides of an 8 by 10½ inch typewriting paper of moderately heavy grade, has proved very satisfactory for recording these cases.

Evidence of staining from chemicals or of various kinds of treatment should be recorded.

One occasionally sees individuals who try to pass off some contagious skin disease—such as scabies, pediculosis, or impetigo—as a skin disease of industrial origin; or one may see cases of psoriasis or diseases originating at home which are thought to be industrial. Such patients, perhaps called malingerers, should be watched for. Syphilis should always be borne in mind, particularly because of the tendency of syphilis to present itself at a point of trauma, and because such a manifestation is seen

often enough to warrant placing special emphasis on this condition. In any long-continued condition a blood examination, not only a blood count and smear but a Wassermann test, should be made.

Diagnosis

All cases of occupational skin disease should be included under some one term rather than scattered under various terms such as acne, dermatitis, or eczema. This disease group is of sufficient importance to warrant a definite place in our official classification. Let the diseases be classified as well by cross filing under the terms usually applied to the manifestations, but let them be grouped under some term in order to be available for future inspection and study. I have previously suggested the term *Dermatosis Industrialis*, but it makes little difference what the term is as long as it is universally agreed upon and applied to these cases. Such a term, however, is not enough. It covers too wide a variety of manifestations and requires qualifying terms. In recent years the classification of heart disease has been clarified by the adoption of a more uniform use of terms, and it would seem possible to define this group of skin conditions in a somewhat similar manner.

The use of the term *Dermatosis Industrialis* can be qualified by the use—in parentheses, perhaps—(1) of words characterizing the type of eruption which predominates, and (2) of words signifying the causal factor if known, and if not, the occupation. The following examples will suffice to indicate the scheme:

Dermatosis Industrialis (acute dermatitis—paint remover)
Dermatosis Industrialis (chronic dermatitis—shoe ironer)
Dermatosis Industrialis (folliculitis—oil)

In these industrial cases where so much depends on the history, since the manifestation can be produced by other causes, there is oftentimes much difficulty in determining absolutely the industrial responsibility. The best we can do is to classify them into (1) the perfectly definite industrial cases; (2) the "probable" cases, where some slight doubt exists; and (3) the "doubtful" or "possible" cases. These last include cases in which (*a*) there is an indefinite history of exposure to some irritant; (*b*) the individual is working with substances of doubtful irritant properties; (*c*) there is another possible explanation; (*d*) there seems to be no other possible cause; and (*e*) those about which not enough data are recorded. A study of cases along the lines which I have indicated should decrease the number of cases in this group.

Then there is the group of cases which careful examination shows are definitely not industrial; such cases show a very doubtful or no relation to industry, findings improbable from the nature of the work, or a definite picture of some known skin disease. I mention this class only for the purpose of emphasizing the necessity of making a record of the fact that a suspected case is definitely not industrial after as much information as possible has been obtained. Furthermore, in the examination of suspected industrial cases there frequently occurs the non-industrial case which may be contagious (impetigo, scabies), and it is well to emphasize this fact in any record or report which is made.

Treatment

Space should be provided on the record card not only for a note regarding the local and general treatment of the individual case and for observation, but

for recording the results of the investigation of the process or substances involved, and the preventive instructions indicated; that is, it is well to indicate whether any mechanical prevention, such as the use of gloves or a greasy application previous to going to work, is suggested, or whether any chemical may be employed as a preventive, or whether it may be necessary to suggest altering the work process in some way or other. One should also indicate whether it is necessary for the individual to give up his job temporarily or permanently, and should summarize the advice given to the individual about going to work. In addition it is well to state whether or not hospital treatment is indicated. There are many factors which interfere with the full adoption of preventive measures in many cases, but at the same time it is well worth while to record the measures which are indicated, and at some later date to note whether they were adopted.

Conclusion

In conclusion it may be said that the adoption of such a system as I have outlined should make the examination of the individual case more thorough, should accelerate this examination, should provide for more ready reference and study, and should aid in standardizing reports and results. Furthermore, a study of records compiled on such a basis can be depended upon to furnish the exact information necessary for the more accurate solution of some of the problems of industrial skin diseases.

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SOME OBSERVATIONS ON INDUSTRIAL LIGHTING*

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Introduction

INDUSTRIAL lighting today covers such an extended field that a review, however superficial, of the whole subject would be impracticable in a single paper. With the growing recognition that lighting is an important factor both in the comfort and well-being of the operatives and in production, it has received greater attention in recent years, but a good deal of misconception still remains, and discussion is often rendered difficult owing to unfamiliarity with technical terminology. For example, a temperature of 60° F. is understood at once, whereas the expression 3 foot-candles generally conveys no meaning unless it is more or less elaborately explained. The object of this paper is to touch on certain aspects of the technic of illumination, based chiefly on the proposals put forward by the Factory Lighting Committee in the reports which it has issued; but before this can be done reference must be made to the common terms used in the science of illumination.

Terminology

1. Luminous Intensity.—The candle is the unit of luminous intensity, and is applied chiefly to the source of light. One speaks, for instance, of an 8, 16, or 32 candle-power source, meaning that the luminous intensity of the source is equal to 8, 16, or 32 standard candles (approximately the same as any ordinary candle).

2. Illumination is measured by the amount of light *received* on a surface, and can be expressed in terms of units of light flux incident on unit area of surface. In practice, however, it is usually expressed in another way—namely, in terms of luminous intensity (*i.e.*, candles) and distance. The unit employed is termed the foot-candle, and is defined as the illumination received on a surface placed normally (*i.e.*, at right angles to the direction of the light) at a distance of 1 foot from a point source having a luminous intensity of 1 candle.

Illumination, being the amount of light *received* on a surface, is independent of the nature of the surface and is the same, for instance, whether the surface is white or black. This does not mean of course that the illumination *required* is the same in both cases, as will be seen in considering the next term.

In dealing with illumination, three important laws must be taken into account; these laws apply, strictly speaking, only to point sources of light, *i.e.*, to sources whose size is negligible compared with their distance from the surface.

a. Illumination varies directly as the candle-power of the source; ***e.g.***, a source of 10 candles will under the same conditions give an illumination 10 times that of a source of 1 candle.[1]

*An address given before the National Council of the Pottery Industry. Received for publication Oct. 22, 1923.

[1] To reproduce various illuminations on a small surface for demonstration purposes the following method is recommended.

Make a simple flat screen of dull black paper.

b. As is generally known, illumination varies inversely as the square of the distance from the source; *e.g.*, if a surface is placed 6 inches from a source of 1 candle, the illumination will be 4 (not 2) foot-candles; if removed to a distance of 2 feet, the illumination will be ¼ (not ½) foot-candles, and so on. Hence the illumination increases or diminishes very rapidly as an object is approached to, or removed from, the source.

c. Illumination varies according to the inclination of the surface. It is greatest when the surface is normal to the direction of the light; with an inclined surface it varies as the cosine of the angle of inclination. In most industrial processes the plane of work is horizontal, or nearly so, so that the ordinary system of vertical lighting is theoretically the most efficient; but cases arise where the plane of work is inclined or even vertical, and under such circumstances this principle may become of importance. It is also relevant when the illumination of the floor or of an object some distance from the source of light is under consideration.

3. Brightness is measured by the amount of light *returned* from a surface and is the most essential factor to be taken into account in industrial work, since the power of seeing depends on the light returned from the object to the eye.

The brightness of a surface depends, first, on its illumination (*i.e.*, the amount of light received by it) and, secondly, on its capacity for reflecting the light received by it. For example, let us consider some process (such as hand sewing) involving the use of differently colored materials. If the material is white, it will reflect about 80 per cent. of the light received, and with an illumination of 3 foot-candles its brightness or its degree of visibility will be represented by 2.4. If the material is black, it will reflect about 0.8 per cent. of the light, and with the same illumination its brightness will be 0.024, or 1/100 that of the white. In order, therefore, to bring the brightness of the black material up to that of the white the illumination must be increased 100 times.

This example shows the important part played by the color of the object or material. The capacity for reflecting light, or the so-called "reflection ratio," is an essential factor to be taken into account whenever work involves the use of different kinds of material.

The term *brightness* has replaced the older term *intrinsic brilliancy*, and is now also applied to a light-giving source. It is then measured in terms of candles per unit area of surface.

cloth, or velvet, and attach it by means of a clip to an ordinary candle, so that the flame is completely invisible to the observer when standing behind the candle. Having completely darkened the room, light the candle and allow it to burn for at least five minutes. Then take a white unglazed card or piece of white blotting paper about 3 inches square, and fix it on a level with the flame in an exactly vertical position, preferably by means of a stand. Adjust the distance from the flame according to the table below, and the effect of the corresponding illumination, *as received on a white surface*, will be seen.

By using cards of different colors and shades the effects of various illuminations, *as received on other than white surfaces*, can be studied.

Horizontal Distance of Surface from Flame		Illumination (Foot-Candles) Received on Surface
ft.	in.	
2	0	0.25
1	0	1.00
—	7	3.00
—	5⅜	5.00

The above illuminations, especially the higher, are only very approximate, but are sufficiently correct for demonstration purposes. The appropriate distances for other illuminations can be calculated from the formula:

$$D = \sqrt{\frac{1}{E}}$$

where D is the distance in feet, and E is the illumination required.

Brightness in this sense frequently arises in questions of shading and glare. In its second report the Factory Lighting Committee suggests that certain sources should be exempted from the requirements dealing with the placing of lights relatively to the eye. These exemptions are limited to sources with a brightness of not more than 5 candles per square inch.

Adequacy of Illumination

Adequacy has now been dealt with by the Committee in two of its reports. In the first report it was considered from the point of view of general lighting, that is, of allowing easy access from one part of a factory to another, and certain standards were recommended as minima. For instance, a minimum of 0.25 foot-candles at floor level was suggested for ordinary work-rooms.

The third report deals with adequacy from the point of view of the work, and suggests that processes should be divided into three categories:

a. Very fine processes, for which a minimum of 5 foot-candles is suggested.

b. Fine processes, for which a minimum of 3 foot-candles is suggested.

c. Other processes, which it was thought might provisionally be covered by the recommendation in the first report requiring a minimum of 0.25 foot-candles, on the ground that this minimum at floor level would involve a much higher average at the working level.

It will be seen, therefore, that the question of adequacy generally has been treated in a rather tentative way. This is due partly to the extreme complexity and extensiveness of the problem—which, for complete solution, would involve separate study of every industrial process—and partly to the feeling on the part of the Committee that definite legal requirements are undesirable at present. Indeed, so far as my experience goes, instances of really inadequate illumination in the case of very fine processes are rare, simply because the work cannot be satisfactorily carried out under such conditions and the quality suffers.

There are, however, two practical points in connection with adequacy which are perhaps worth mentioning as they both relate to the best use that can be made of a system of illumination. In the first place, the efficiency of any system of illumination depends upon its maintenance; in the case of direct lighting, it depends upon the cleanliness and state of efficiency of the source and shade; and in the case of indirect lighting, upon the cleanliness of the ceiling and walls as well. From this, two practical conclusions follow: first, that inasmuch as half the possible light may easily be lost through dirty globes, defective gas-mantles, etc., it is in the interests of economy that these should be periodically cleaned and replaced; secondly, since the sources and decorations obviously cannot be kept in their original state of efficiency, allowance for deterioration should be made in planning any system to attain a given standard, and the standard initially reached should be considerably higher than that eventually aimed at.

Again, light is sometimes wasted (and unnecessary glare produced) by placing the source too low, under the mistaken impression that the illumination is thereby increased. Let us, for instance, imagine a double work-bench lighted by a single row of lamps down the center. With this arrangement the source is not vertically above the place of work, and the simple inverse square law of illumination alone no longer holds, since the cosine law also comes into play. In such

a case there is one definite height of the source above the bench at which the illumination is at a maximum, and fixing the source below this point not only increases the glare but also defeats its own ends in that the illumination is actually reduced.

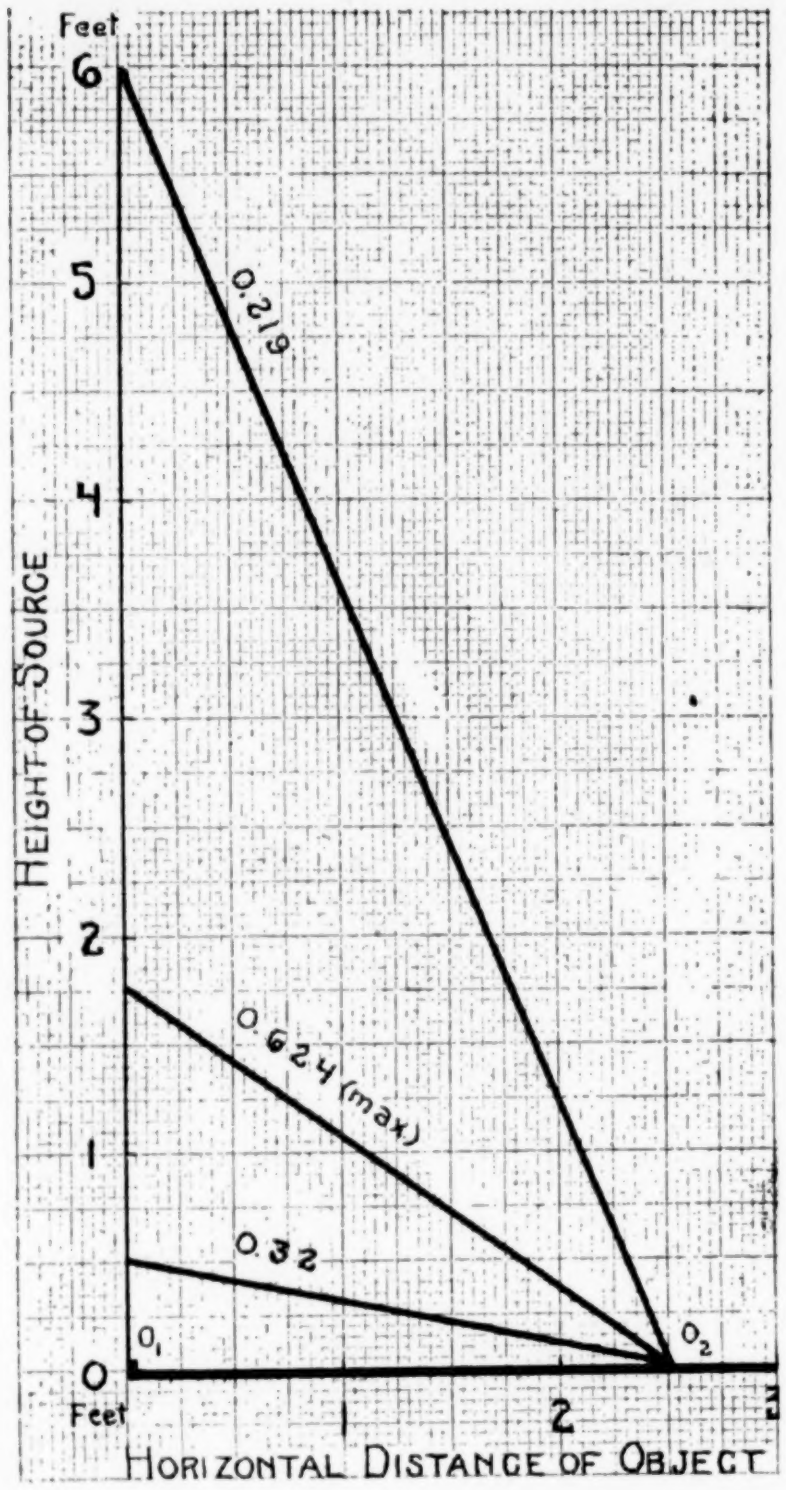

FIG. 1.—Illumination produced by a 10 candle-power source at different heights on a horizontal surface placed at a horizontal distance of 2 feet, 6 inches from the source (0_2).

Table 1 and Figure 1 show the illumination produced by a 10 candle-power source at different heights on a horizontal surface placed (*a*) vertically under the source (0_1) and (*b*) at a horizontal distance of 2 feet, 6 inches away from the source (0_2); such a surface may be taken as illustrating bench work

TABLE 1.—ILLUMINATION PRODUCED BY A 10 CANDLE-POWER SOURCE AT DIFFERENT HEIGHTS ON A HORIZONTAL SURFACE PLACED (a) VERTICALLY UNDER THE SOURCE (0_1) AND (b) AT A HORIZONTAL DISTANCE OF 2 FEET, 6 INCHES AWAY FROM THE SOURCE (0_2)

Vertical Height of Source		Illumination	
		at 0_1	at 0_2
ft.	*in.*	*f. c.*	*f. c.*
0	6	40.000	0.320
0	9	17.250	0.420
1	0	10.000	0.512
1	3	6.400	0.575
1	6	4.450	0.610
1	9	3.260	*0.624*
2	0	2.500	0.610
2	3	1.980	0.592
2	6	1.600	0.565
3	0	1.110	0.504
4	0	0.625	0.380
5	0	0.400	0.286
6	0	0.278	0.219

of a common type. When the surface is immediately under the source, the illumination falls off very rapidly, as the height of the source increases, from 40 foot-candles at 6 inches to 0.278 at 6 feet according to the law of inverse squares. When the surface is 2 feet, 6 inches distant from the source in a horizontal direction, the illumination is, of course, initially much lower owing to the fact that the surface is no longer normal to the direction of the light, though it tends to approach the illumination in the other position as the height of the source increases. The important point to notice, however, is that in this case there is one height (1 foot, 9 inches) at which the illumination is at a maximum, falling off as the height of the source is altered in either direction.

SUITABILITY OF ILLUMINATION

If there is often little fault to be found with adequacy, the same certainly cannot be said of suitability, and the large majority of factories are capable of more or less improvement in this respect.

Glare.—The Committee distinguishes between three forms of glare. The first may perhaps be termed pathological glare, as it produces, or may produce, a definite lesion of the eye. It may be defined as the effect of looking directly at a bright source of light, whereby the eye is flooded with light. Extreme instances of this type of glare might occur in such processes as electric and acetylene welding and steel making, but protective glasses are universally worn, and in any case the effects produced, being primarily of medical interest, are outside the scope of this paper.

There is, however, a less extreme application of this type of glare which has a direct bearing on ordinary factory work, and especially safety. When a man even glances directly at a bright light, he is dazzled and his vision is temporarily impaired. The result is that, given the existence of some potential risk, his liability to accident is increased. Take, for instance, a man entering a crowded foundry with unshaded, high-intensity light sources; his eye is adapted perhaps to almost complete darkness. As he enters, a bright light strikes his eye; he is dazzled and fails to see an obstacle at his feet, and so his case becomes another addition to the long list of accidents due to falls. But for the glare he would probably have distinguished the object without difficulty. Similar considerations hold, of course, in regard to almost any process involving machinery in motion. Thus glare may prove to be as important a factor in accident causation as insufficient illumination.

The second form of glare, which is really a modification of the preceding form, may arise when the material handled is polished or shiny. In certain positions, all details become indistinguishable owing to specular as opposed to diffused reflection of the light. This effect is often noticeable in picture galleries when glazed pictures are viewed from a certain angle. What happens, of course, is that the polished material acts as a mirror. This type of glare differs from the first only in that the eye is confronted with an image of the source instead of with the source itself. It is very likely to occur in any process dealing with polished material. It is so detrimental and prohibitive to work, that it *must* be avoided by the worker, and if suitable objective remedies are not applied he is likely to adopt a strained attitude which may eventually have injurious effects.

The third form of glare arises when a bright source of light is placed near, though not in, the line of vision. Even though the eye is not looking directly at the source, its presence may be a cause of distraction and some annoyance. This may be due to the fact that the rays of light strike the eye obliquely and reach the periphery of the retina, or it may be of purely psychological origin. It is very common in practice, but is seldom the subject of complaint because the effects are not very intense.

Remedies for Glare.—These may be roughly classified into two groups:

a. The introduction of some means of protection between the eye and the light source.

b. Change in the position of the source relatively to the eye.

The first of these may assume various forms in practice. First, there is the wearing of colored or smoked-glass spectacles—the only remedy in the cases of sources of very high intensity, which cannot be shaded otherwise. Apart from cases of this kind, however, the use of colored spectacles is generally confined to persons with defective eyesight.

Secondly, the light may be completely

screened from the eye by means of opaque material. In adopting this method, care should be taken to insure that the screen is sufficiently deep to prevent the direct light from falling on the eye and yet is not so deep as to cut off the light from the object. A fraction of an inch in this respect may make all the difference between a good and an unsatisfactory system of screening, when, as is often the case, the eye and the object are placed close to one another.

Thirdly, the source, instead of being completely screened, may be reduced in brightness until it is no longer harmful to the eye, even when looked at directly. The Committee paid special attention to this question and virtually recommended that sources whose brightness does not exceed 5 candles per square inch (approximately that of the sky) should be exempted from all restrictions as to glare. This reduction is most conveniently brought about by surrounding the naked source with a globe or other shade of translucent material such as opal glass. The effect of doing this is to make the globe itself the source instead of the incandescent surface, so that the total candle-power is now distributed over a much larger area.

The reduction in brightness in any given case can be calculated quite simply. In general, the reduction in brightness brought about by surrounding a source with a translucent globe must be at least equal to the ratio of the two diameters squared. Actually, of course, the reduction is greater, as a considerable fraction of the light is absorbed by the material of the globe, so that the total candle-power of the globe is less than that of the source itself.

This matter is referred to in some detail in order to indicate how easy it is to bring down the brightness of a source to reasonable limits. For example, the brightness of a 100 candle-power gas mantle would be reduced to the recommended limit of 5 candles per square inch by the use of a globe about 3 inches in diameter; that of a 2,000 candle-power arc light by the use of a globe less than 1 foot in diameter, and so on. As the criterion of whether the reduction of surface brightness is sufficient, the Factory Lighting Committee has suggested that the details of the source should be indistinguishable through the shade.

Two of the methods just described—namely, completely screening the source and shading it with translucent material—have advantages and disadvantages.

Screening the source, especially if the screen is lined with white, has two advantages: (*a*) None of the light is lost through absorption; (*b*) the light can be concentrated when it is needed. It is, therefore, specially suitable for the local lighting of work. On the other hand, it has the disadvantage of contributing little to the general lighting of the room, so that when it is adopted other units for the purpose of general illumination should often be installed in addition. Furthermore, it requires care in planning, and unless scientifically designed shades are used, glare, as defined by the Committee, is likely to persist in the room generally. It must be remembered that the relation of every person to every source within 100 feet must be taken into account, and it is quite possible to screen a source from the worker whom it serves and leave it exposed to other workers, such as those at a neighboring bench. This is specially likely to occur when lamps of one size and shape are used in screens adapted for another, as is apt to happen whenever a new type of lamp is placed on the market.

Shading, as opposed to screening, has the advantage of affording general as

well as local lighting, though some light is lost by absorption. Also, when once a source is adequately shaded, glare is removed once for all and no question of position arises. In itself, therefore, it is perhaps preferable for processes in which specially good lighting is unnecessary. A practical point of some importance is that translucent *shades* are easily broken, whereas metal *screens* are not.

The second method of remedying glare is concerned with the position of the source relatively to the eye. The Committee closely considered this point and virtually recommended that no unshaded light source (unless below a specified brightness) should be visible within a vertical angle of 30° with the eye-level, if within a distance of 6 feet, or, if situated at distances from 6 to 100 feet, within a vertical angle of 20°. Table 2 shows the minimum heights at which

TABLE 2.—MINIMUM HEIGHTS ABOVE EYE-LEVEL AT WHICH SOURCES MUST BE FIXED IN ORDER TO PREVENT GLARE

Horizontal Distance of Source from Eye	Minimum Height of Source above Eye-Level	
ft.	*ft.*	*in.*
1	0	7
2	1	1¾
3	1	8¾
4	2	3½
5	2	10¾
6	3	5½
7	2	6¾
8	2	10¾
9	3	3½
10	3	8
20	7	4
40	14	8
60	22	0
80	29	4
100	36	3½

such sources must be fixed in order to comply with these conditions. Figure 2, which gives the minimum heights above floor-level, illustrates the same requirements.

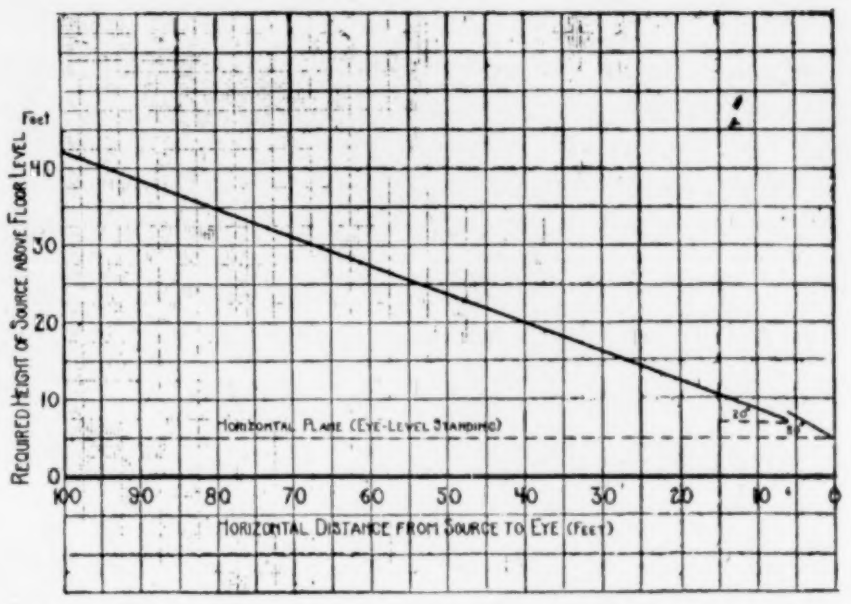

FIG. 2.—Position of source in order to prevent glare.

The foregoing recommendation applies to every unshaded light source within 100 feet *relatively to every person employed in the room*, and, if adopted, will have far-reaching, though beneficial, results. It will, for instance, eliminate all such sources as naked arc lamps from large workshops and will necessitate a thorough overhauling of the lighting arrangements in many factories.

One common type of glare—the glare which is likely to occur with work on polished material—offers certain peculiarities. In this case the eye is confronted with an image of the source reflected in the material worked upon, so that the object itself is the origin of the glare and not the source of light. Hence *screening* the source from the eye is no remedy.

There are two means of overcoming this form of glare. The first is based on the relative positions of the eye, the object, and the source. We know that specular reflection is subject to two laws: first, that the ray of light falling on a surface and the ray reflected from it are in the same plane; and, secondly, that both rays form equal angles with the perpendicular to the surface. If, therefore, the object possesses a smooth polished surface, this form of glare arises

only when the eye is in one position relatively to the source and object, and can be eliminated readily by moving either the eye or the object in almost any direction. Many "shiny" objects, however, are not really smooth, but consist of small polished surfaces placed at different angles; this, for instance, is the case with certain textile materials such as satins. Here the method under consideration is generally ineffective, since however the eye, object, and source may be placed relatively to one another, some of the small surfaces will always be in such a position as to "catch the light," *i.e.*, to act as tiny mirrors reflecting light directly into the eye. The second remedy is efficient shading of the source. The ultimate effect of this, of course, is to reduce the brightness of the image of the source to a limit which can be tolerated by the eye without discomfort. Tissue paper is an excellent diffusing material, and has been used with success to surround the light sources in the case of copper plate engraving, a process in which this type of glare is specially likely to arise.

Shadows.—The treatment of shadows is in theory quite simple, though in practice certain difficulties arise. In general, interfering shadows can be removed in three ways.

The first is the radical remedy of changing the system of lighting. The depth of a shadow bears a direct relation to the size of the light source, and, as we shall see later, shadows in daylight are generally less pronounced than shadows in artificial light, because in the former the light is received from surfaces (namely, windows) instead of from points. It is possible in artificial lighting to reproduce to some extent this characteristic of daylight by replacing the common system of direct lighting by indirect or semi-indirect. In these methods, of course, the light is no longer received exclusively from points, but in the former method all, and in the latter much, of it is reflected on to and back from the ceiling, which is a surface of considerable extent. In other words, the light in these cases is more diffused. Indirect lighting, in fact, is practically shadowless, and this very characteristic is something of a disadvantage; with semi-indirect lighting, there remains a faint, harmless shadow effect, but the general character of the illumination is usually considered to be preferable. These methods are best adopted in rooms with flat and not too high ceilings and are less suitable for the shed type of room, though they can also be applied here by the use of what are called false ceilings.

The second remedy depends on the relative positions of the light source and the object responsible for the shadow. Every shadow is cast in the same straight line as the object and source, and if in any one position a shadow is found to lead to discomfort it is often possible to remove it to another situation where it is harmless simply by altering the position of the source. For instance, compositors may sometimes be seen working in their own shadows cast on the cases by a lamp over a neighboring frame; by moving this lamp a foot or two to the right or left, the man's shadow is no longer cast on his case but to the left or right of him.

The third remedy consists in eliminating or reducing the shadow effect by placing an extra lamp in such a position that the part where the shadow is cast receives extra illumination. This is an obvious method which calls for no further explanation.

Moving shadows such as are cast by parts of machinery in motion are often particularly trying. They frequently

offer cases of considerable difficulty, but the effect can usually be overcome, or at least reduced, by one of the methods already suggested.

Natural and Artificial Lighting

Natural lighting, at any rate in modern factories, is, of course, far the more important because of the length of time during which it is in use. The Factory Lighting Committee has not paid much attention to it *per se,* but its recommendations as to standards of adequacy and such matters as shadows may be taken as applying to natural as well as artificial illumination.

There are, however, a few points relating to daylight to which attention should be drawn. Daylight is admittedly superior to most forms of artificial light not only on account of the quality of the light, but also for other reasons. With daylight, for instance, the sources of light (the windows) are surfaces, instead of points as in the usual types of lamps. This fact makes the formation of shadows much less pronounced and, so to speak, increases the penetrating power of the light in cases where shadows are a difficulty. For example, in the case of fine weaving, it has been found that production in artificial light, even when the illumination amounts to what is generally thought to be adequate, may be 10 per cent. less than in daylight —a reduction probably to be ascribed to the more intense shadow effects which are a great hindrance in the operation of certain types of loom. Furthermore, no acute glare arises in natural lighting, for the source of light (the sky) has normally a brightness which can be tolerated without discomfort by the eye. It follows then that (if we except direct sunlight) the greater the quantity of natural light admitted, the better. In fact, the quantity should be as great as structural exigencies permit, subject of course to realization that a large expanse of window space makes a work-room specially susceptible to the cold and heat of the outside air. The eye can adapt itself without discomfort to large variations in illumination, and, if the direct sun (which may produce an illumination of several thousand foot-candles) is excluded, there is no risk of the illumination being too high. Neither is there any waste in this practice, for the greater the amount of daylight admitted, the later the lighting-up time becomes and the shorter the period of artificial lighting.

Apart from the question of window space, the natural illumination of a room can be greatly increased by the systematic observance of certain rules laid down by the Factory Lighting Committee in its first report. First, all windows should be kept clean, for the obstruction to light by even slight dirt may be very heavy, amounting easily to 50 per cent. The period between cleanings will, of course, vary with the nature of the work, but cleaning should be carried out systematically; in some factories a man is employed to do nothing else. Secondly, windows should be kept clear of obstructions, such as large articles piled on one another, so that the light from them may have free access to the interior of the room. Lastly, the walls and ceilings should be clean and light in color so as to act as efficient reflecting surfaces. This is especially important in small rooms, in which white walls and ceilings may increase the effective light fivefold as compared with black walls and ceilings.

Natural illumination has been much less studied than artificial, and there still remain many questions in connection with it which require to be cleared

up. The whole question of natural lighting, however, is one *primarily* for the architect; in old factories the only thing to do is to make the best of a bad job, and to apply the palliatives mentioned in the Committee's first report.

There is, however, one important principle which is perhaps worth mentioning here. Everyone is familiar with the superiority, with regard to lighting, of a shed roof over side windows. This is largely due to the approximately vertical direction from which the light comes. By extending this principle to side windows, it is easy to realize that the top part of the window is enormously more effective than the bottom. It follows, therefore, that windows should be constructed so as to reach right up to the ceiling, every additional inch in this part having a considerable effect.

Conclusion

The theoretical requirements of good lighting are simple and it is an easy matter to generalize in the way attempted in this paper. When we come to apply these requirements in practice, however, we find that while there are certain fundamental conditions which every good system should fulfil, difficult, and even extremely difficult, cases frequently arise which can be solved only by the method of trial and error. Whenever a system of lighting is about to be installed in a factory, careful consideration should be given to these general conditions before the work is begun, and before it is completed the employer should satisfy himself by actual experiment in the way of adjustment that the best results have been attained.

Many admirable examples are to be seen of installations in the design of which the employer has collaborated not only with the expert illuminating engineer, but also with the workers concerned. On the other hand, factories exist where every canon of good lighting has been broken simply through want of thought, typified in the use of shallow, conical covers (relics of the old carbon lamp days which ought to be completely abolished) instead of scientifically designed shades, wrong spacing of the points relatively to the plant, and many other faults.

Lighting differs fundamentally from other factors in the workers' environment. In the case of temperature and ventilation, convection and diffusion come into play, and we can safely say that the conditions at any point are approximately reproduced at any neighboring point. In lighting, this is not so; light travels irresistibly in straight lines, and so it is often possible to find conditions at one point entirely different from those at another a few inches removed from it. As a corollary, it follows that the complete solution of a lighting problem often offers difficulties of a very special nature; but on the other hand when once these difficulties have been overcome and satisfactory conditions have been attained, these remain unchanged and unaffected by external influences, which so often become interfering factors in the case of the other great divisions of factory hygiene.

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THE FUTURE OF THE CHILD LABOR QUESTION*

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INTRODUCTION

TO the cursory observer the child labor problem appears to be one of admitted importance but one which is easily solved. Until I had an opportunity, as Director of Health and Hygiene in the New Bedford, Mass., School Department, to study the situation in the local textile industry and to notice how many-sided the situation was, even in one community, I was convinced that about all that was necessary was to prevent children from going to work as long as possible, preferably until they were 18 years old, and that disaster was sure to result unless this rule was strictly carried out. This is probably the view of the majority of persons who interest themselves in the child labor question, but when they have really studied it, they become appalled by the difficulties which arise in attempting a solution—and, be it said, a practical solution is urgently needed. Even persons unfriendly to strict child labor legislation admit that in certain occupations, such as truck gardening, work in the shrimp industry, sweat shops, and beet fields—the examples commonly quoted—there is much to be criticized.

From a strictly sentimental point of view *no* child should engage in gainful occupation because of the serious physical condition in which certain child laborers have been found, the long hours and the more or less unhealthful surroundings in which they work, and the problems of adolescence and growth. Nevertheless no satisfactory solution can be reached through sentiment alone. What the situation demands is a code, as satisfactory as possible to all concerned, which will permit children to work, at least in certain definitely understood situations, but which will prevent the evils of stunted minds and bodies as well as temporary or permanent injury of any kind to the growing youth.

PHASES OF PROBLEM

Child Labor and the Child.—No child should be permitted to work at any task which is potentially injurious to him or her individually. The necessity of preceding permission to work by a thorough physical examination in order to discover any condition which would make a definite kind of job undesirable is obvious. The opinion of the examiner would be even more valuable if, in addition to knowing the specific task, he also knew the exact conditions under which the child was to work, since children employed in the same task in different mills often work under widely different conditions, and this fact is worth considering. The number of hours per day must be commensurate with the child's physical strength. The standards of the Children's Bureau at Washington, after modification and adaptation to the needs of a particular state, form the basis of most child labor laws of today. The Massachusetts Labor Laws, when carried out as intended, have proved adequate and satisfactory, and represent much careful and commendable study. Although based partly on age, they thor-

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oughly recognize the need of physical fitness for a given job. Under the laws of this state 14 is the minimum age at which a child may be employed, and certification is required until a child is 16. The sixth grade must have been attained except in special cases where a waiver is given.

Child Labor and the School.—The argument is often advanced that we must not only protect the body, but we must give the mind every opportunity to develop to its limit. This point is at once granted. Recent work with mental tests, however, suggests that the individual mind varies considerably in potential ability to accomplish and in aptitude. Thus the schools of any community contain all gradations of pupils from those who may turn out to be geniuses if properly handled down to those who may at any time need the care of a special institution for persons of low mentality. Fernald has even worked out a table which will give the approximate grade in school which many of these children can reach with their mental equipment. Obviously ordinary education beyond this approximate point may prove a mere waste of time.

Mental tests also are of considerable assistance in determining a child's aptitude for some particular field, such as mechanics. Although this phase of psychology, which is freely exploited by some in the manner formerly used by phrenologists, is still in the experimental stage, it has led many to wonder whether we should attempt to make a classical scholar of a child whose every interest is in mechanics. No one denies, however, that in the case of children of higher mentality, a general background is desirable before specialization. The study made by Woolley (1) suggests that child laborers are often children of low mentality.

In most schools certain children are found who are firm in the feeling that they have had enough. Some have lost interest in study and some have reached the stage which represents the limit of their powers. The junior high school, with its varied program, some part of which *must* appeal to *every* child, is held up as the solution of the indifference complex, and such an institution, properly organized, undoubtedly prevents an early end to the education of many.

Some people feel that, regardless of any learning which may be acquired as such, school is desirable for all children because of the control which the school exercises over its pupils and because the school atmosphere tends to be more inspiring than that of the mill or the street corner. As a matter of fact, it was for the purpose of giving working children the advantage of exactly these influences that the continuation school was devised.

Dissatisfaction with school may arise from parental propaganda. Certain races apparently indulge in a consistent campaign against education beyond a certain point (usually that at which the law permits the child to go to work). One race often withholds meat from a child until he goes to work. The sneers of his parents, together with the fact that he assumes an entirely different and more respected status in the family when he becomes an earner, have caused many a child to lose interest in study and to support his parents in their desire for his exploitation.

Economic reasons sometimes demand that a child leave school and begin earning. Large families, sickness, desertion of the household by the chief breadwinner—all these and similar causes compel children to seek wages. Nevertheless many cases reputed to be in this group are found on investigation really

to belong in the exploited class.

Child Labor and Parents.—The attitude of parents toward child labor has been discussed indirectly. The majority simply do not realize that control of the situation is for their child's good. When this is brought to their attention and someone takes time to explain the matter to them in a friendly manner, a different attitude is sometimes forthcoming. Some thrifty parents believe that they are honestly entitled to have financial aid from their children after a certain age, and the earnings are used to better home conditions or to buy property.

Child Labor and Employers.—Many employers do not care particularly to employ child labor. They do so as a matter of meeting competition and at times as a favor to an employee who wishes a job for his child. The difference between the labor laws of two states may have an important bearing on competition. Thus the Massachusetts Labor Laws require attendance at continuation school once a week for children under 16 years of age, and this time is taken out of the child's working day. The Rhode Island laws do not impose such conditions. As a result, a Massachusetts manufacturer is placed under a slight handicap which must be made up in some other way. (The Massachusetts Law is the right one, nevertheless, because it provides better control of the child.)

What employers need, if they use child labor at all, is a standardized national code which will place competition on an equal basis everywhere. I believe that such a code would receive good support from the really important groups of employers. Child labor is desirable because it is cheap and because it is successful at certain definitely known simple tasks. Using more expensive labor means greater cost for the consumer.

Many employers consider that the early stages in an industry, particularly of the skilled or semi-skilled type, are of the nature of training, as a result of which a child, after spending a certain amount of time learning a few rudiments, starts at a pace which will permit him to be a skilled operative on attaining his majority.

Conditions in New Bedford

When in New Bedford, I was able to study for one year a group of children, 14 and 15 years of age, who applied for working cards and who returned for further examination on change of position, and to compare this group with a group of grammar school children of the same ages. This study (2), the report of which is about to be issued, was made possible through a grant from the Committee on Scientific Research of the American Medical Association. The New Bedford situation offers many suggestions of value but should be clearly understood before the findings of the two groups of children are compared.

New Bedford is one of the old and important textile centers. The original Yankee whaling population has been augmented by English, Portuguese, Azorean, and French Canadian workers and by a few persons of other nationalities. Working conditions are constantly being improved and are carefully observed by the inspectors of the Massachusetts Bureau of Labor and Industries. Many employers have given excellent co-operation and have often provided rest and first-aid rooms and adopted safety devices before any demand was made for them. Wages are better than the average for the industry and the employees are apparently satisfied, if lack of labor troubles is a standard.

Americanization work is active and effective. Industrial athletic leagues receive some support from employers. Some mills employ child labor, some do not. The city is admittedly unusually well supplied with public parks and presents fewer housing problems than most cities, even the smaller ones. School health work has been active and good for over ten years and, with my coming, was done under the direction of a full-time physician.

It was my duty to organize the certification of the working children and to correlate it with the regular school health work and the health work in the continuation school, which was started during my term of office. My predecessor in the certification work had checked a few children by re-examination where indicated and had found no injury to health as a result of working.

A special suite of offices was built for this work in a central location, definite office hours were fixed and conscientiously kept, and each child, in addition to bringing a yellow promise of employment card stating the task and number of hours of work, brought also his cumulative health record from the school. Although the system of keeping school health records was installed the same year, it furnished valuable information even in that short time and undoubtedly will become increasingly valuable. As thorough an examination as could be given without arousing adverse comment was made in each case and the findings were carefully recorded. The adolescent girl resents physical examination except such as can be done through the shirt-waist, and this feeling was and must be respected. Possibly a different situation might obtain if such examinations were made by a woman physician.

Children were passed, passed conditionally for a brief period of weeks or months, or turned down permanently or temporarily. Each child, as well as each position, was given individual consideration (3). A child blind in one eye was not permitted to work in a room with machinery, even though it was well guarded; a child markedly under weight and in danger of pulmonary disease was permitted to work outdoors only, if at all. A definite attempt was made to assist those who were refused cards to secure suitable jobs, and this was sometimes successful. Some children were urged to continue school, and the matter was discussed with their parents, with varying results. From the start, the policy of the continuation school was to encourage a return to day school whenever it was evident that the child was becoming tired of an industrial life, and the schools made every attempt to welcome the prodigal.

No effort was spared to make the certification one of value and reliability, perhaps almost a guarantee of a certain quality of employee, and the work received good support from employers and employees. Little complaint was made and most parents, when a defect was demonstrated to them, sought, if possible, to have it remedied. Glasses were bought which had been needed and urged for several years. Parents realized, as never before, the economic importance of physical well-being for their child. Some children were placed under medical care as a result of defects discovered. Parents were welcomed and careful explanations of the situations and their legal rights were given. Those who decided to use a certain loophole in the law sometimes found that the employer no longer desired the services of their child, although the certification office did not act as informer.

In the continuation school personal hygiene was taught as such and through

other courses, particularly English. Every pupil was weighed every month and a chart was kept. A trained nurse, previously one of the school nurses, was transferred to teach courses in home nursing and child hygiene and to follow up certain special cases referred to her by the physician. Thus the health of the working children was as well safeguarded as that of the children in day school. The continuation school also attempted to offer to its pupils certain social and cultural advantages which they would have had at the regular school. A continuation school is an absolute necessity if we permit child labor.

Here, then, is a good situation. Working conditions are favorable, rather than otherwise. It is not surprising, therefore, that the working groups showed a smaller percentage of children under weight than did the grammar school groups. Furthermore, the children who were working gained in a large majority of cases, usually making a greater improvement than ordinary standards required, and the children who were in the under weight groups made the greatest gains. Thus, among the girls, 73 per cent. of the group who were 10 per cent. or more under weight gained more than the standard of half a pound a month; among a similar group of boys 56 per cent. gained more than a pound a month and 15 per cent. more gained exactly that. The group in this case was composed of 450 children, representing 1,104 examinations.

If we compare this group with a group of 231 grammar school children of the same ages and of the same scholastic attainments, we find that 29 per cent. of the grammar children were 10 per cent. under weight as against 21.68 per cent. of the entire industrial group or 19.43 per cent. of the industrial group who had one or more re-examinations. Other nutrition divisions (7 per cent. under weight, normal, 10 per cent. over weight) differed little, but it is interesting to note that 3.46 per cent. of the grammar children were 20 per cent. or more over weight as compared with 7.09 per cent. of the entire group of industrial children.

These figures suggested to me that the children in employment were, on the average, better physically than the children in the grammar school. In all probability, therefore, the most suitable type of child physically was being permitted to work. The fact that such satisfactory gains in weight were made seems fair proof that the tasks permitted were not overtaxing the group and that health was not injured by working conditions. There was no physical evidence to disprove this idea. A job analysis was in agreement with general findings.

As to five or ten year comparisons, it can only be said that they would be desirable, but practically impossible. One child cannot possibly be observed over more than two years. Funds are rarely available for this type of research which, being partly statistical, is very expensive. Furthermore, so many complicating factors are likely to arise that a very large number of persons would have to be examined to produce reliable data. It is interesting, however, to note the excellent health of certain mill officials who began work of a pretty strenuous sort in the mills in less safeguarded days.

Solution of Problem

Only careful and comprehensive field studies of different industries can give us the solution to the child labor problem. Propaganda has a definite place in arousing public interest. It must have, however, not only facts, but up-to-

the minute facts behind it; out-of-date facts used by a well-meaning writer or speaker not only result in loss of support for the cause among the very persons whose aid would be most helpful, but they also arouse a spirit of doubt and opposition. This is particularly true in industrial centers, where statements about local conditions are made. Field studies are needed both in cities known to be hotbeds of troubles and in cities where good conditions prevail. Those made by Mitchell and the Children's Bureau have quite thoroughly demonstrated that under unfavorable working conditions child labor is distinctly harmful.

I am of the opinion that what is really needed in most cities is the actual observance of the present child labor laws, perhaps with a few minor amendments, rather than any startling changes. A national law, if properly constructed and protective in the right manner, would be ideal since it could remove economic competition between states in the matter. The average employer has little or no confidence in the average certification, and in certain communities it is well known that no examination is made and that popular opinion does not demand it. Yet the certification must be a guarantee of a certain quality of employee if the confidence of employers is to be obtained for the child labor laws. Many physicians are unimpressed by the importance of the card or the whole situation and are paid little for the work. Their attitude is reflected in the attitude of the children and their parents.

The selection of permissible jobs is a matter that is fairly well understood, and not only an expert or an employer but an Americanization worker or an attendance officer can usually tell what jobs are unsuitable and why. The difficulty lies in the selection of physical standards, comprehensiveness of examination, and permissible age.

The physical standards of the Children's Bureau are satisfactory and an excellent guide; the examination should be as careful as can be given without offense (which turns a possible advocate of the scheme into an enemy who will create others). As to the age at which a child should be employed, I differ from many in believing that it is largely to be determined by the physical development and physical welfare of the child. It should never be below 14, but in New Bedford there was no reason to make it higher; in fact there was every reason for using 14 and, as has been seen, no apparent harm resulted.

One difficulty in using 16 as a minimum is that it means an addition of about 10 per cent. to many school plants without a corresponding benefit. To many children, granting right working conditions, extra funds mean better living, greater self-respect through independence, a little money for things greatly desired and heretofore unobtainable, as compared with a school career which is irksome and to which they react unfavorably. For the school it means fewer troublesome pupils who have lost interest in study or who have reached their mental limit. These children, however, often become very different and desirable citizens when they have a job. I have seen just such cases. On the other hand, 16 has the advantage of making careless control of the younger group impossible.

At present there is too great a tendency to emphasize chronological age as the basis for sorting. This is the poorest and most unsatisfactory basis possible. Anyone familiar with the growth of children realizes that two children of the same chronological age may differ

utterly in physiological, or mental, or other "ages" (4). The only justification for using chronological age at all is that we must have some minimum which is absolute. Thus what we actually mean when we use chronological age as a standard is that the average children of the permissible minimum age ought to be able to work at selected tasks without fear of injury to growth (physical or mental). The existence and need of the chronological standard are due simply to inadequate handling of examinations in many instances.

If we could assure ourselves of trained, careful examiners and real system in dealing with the children, then our ideal basis would be physiological age—in other words, physical fitness for a given job under a given employer. Our minimum, then, in all probability, corresponds to the 14, 15 or 16 age. The fact that the employer can often have a choice of several children for a given job automatically assures us of the selection of the best, except in times of heavy production. An interested examiner cannot make many important mistakes provided he is allowed to revoke permits at will, provided children are weighed every month and measured every three months, and provided a general supervision of health is part of the continuation school work. The monthly weight curve soon tells us whether or not the child is overdoing, and in case of sickness the nature of the illness is soon known to the class-room teacher, who is supposed to make follow-up visits to the homes, really for the purpose of shaping her courses to meet actual needs as far as possible.

The greatest difficulty of the new examiner today is that he has to develop standards of his own for his locality. His only guides are the standards obtainable from the Children's Bureau plus, as in Massachusetts, a list of permissible tasks and a general law. The result is that factories must be visited, advice sought from attendance officers and Americanization workers familiar with conditions, and eventually a statistical study made of the effect of different jobs on various types of children. Usually funds are not available.

The greatest needs of the situation all arise from one paramount need—namely, the adoption of a physiological and, to a far less extent, a chronological set of standards. Before such standards can be established, many more scientific field studies must be made under good as well as bad conditions. Ample funds must be available for the work so that physicians can be properly paid, sufficient clerical help hired, and cumulative records kept to supplement and to be filed with the previous school health record. The work of certification must be co-ordinated with the health system of the regular schools and the continuation school, and eventually with industry. Some may maintain that co-ordination between school and industry is effected through the state labor inspectors. Practically this is true only in the case of extremely unsatisfactory certification.

The public must know the true state of affairs. Particularly is it desirable that the public in centers employing child labor should understand what is being done and what end is sought. Appeal to common sense through facts and statistics which are up-to-date will do this. Lurid tales or facts which were true years ago only arouse doubt and opposition. A demonstration of what can be done by the introduction of a good system of handling the certification and an explanation of the purposes behind it is often all that is needed, be-

cause everybody gains—the parent, the child, and the employer.

We are only beginning this work. Sooner or later vocational guidance will be attempted in the examining office; in fact, it was informally tried in New Bedford with fair success. Just as education recognizes mental as well as physiological age, so must industry. Here again the attempt to do so is actually being made, as the studies of Fernald reveal. The social and moral ages are kept in mind as the special province of the continuation school and form one important reason for its existence. I hope that we shall set up standards in all these fields and use them in the certification office. Chronological age and grade in school should be dispensed with as soon as we can improve our management of the certification. For the present they are simply the best that we have. No set of standards can be assured of permanency or anywhere near universal value unless it is able to cover all the different "ages" of the child seeking the certificate to work. Physical defects must be evaluated, just as they are in compensation work, and here again the only answer is through research in the field. I place great hope in the tendency among the progressive small cities toward the employment of full-time medical directors for their school systems.

Conclusion

I have endeavored to emphasize the necessity of field study under all conditions before a final attempt at standardization is made. Present standards are surely a step in the right direction. Advances in the field of education and medicine and the prospect of much greater advances make it advisable to develop a system for handling certification rather than merely rigid standards which are often easily evaded. Such a system must afford economic equality to employers in all parts of the country by removing the element of competition based on child labor. The successful system will be based on the complexity of the child and on the individual child and the individual job and will emphasize co-ordination between the school system and the employer in all phases of the situation. Only praise is to be accorded present efforts by state and national organizations and bureaus. All undoubtedly are working toward a somewhat similar purpose.

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ERRATUM

In place of the fifth line of the first paragraph on page 390 of the February, 1924, issue of THIS JOURNAL, read:

tants'' differ widely in chemical and

ACTION OF IRRITANT GASES UPON THE RESPIRATORY TRACT*

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INTRODUCTION

AMONG the gases and vapors encountered in industrial procedures, the ''irritants'' constitute a large group. The substances designated as ''irritants is the same; the differences in physical properties and in the symptoms which follow their action. Fundamentally, however, the toxicology of all irritants is the same; the differences in symptomatology are chiefly the results of differences in the location of their action. The characteristic symptomatology of any irritant is, therefore, an expression of a pathological state in the particular structure acted upon by the irritant rather than of any dissimilarity in the action of the irritants.

The election of certain localities for action by various irritants is the result not so much of the difference in their chemical properties as of the difference in their physical properties. Once this distinction is comprehended, a knowledge of the physical properties of a gas indicates the area which it will affect and the symptomatology and pathology which will follow. It thus becomes possible to systematize the action of irritant gases and vapors. This paper is an attempt to present such a systematization.

IRRITANTS ACT BY INDUCING INFLAMMATION

An irritant gas or vapor is one which induces the phenomena of inflammation in those tissues with which it comes into immediate contact. The inflammation (''irritation'') is induced by the coagulation, liquefaction, dehydration, or other disturbance of the normal state of balance in living protoplasm caused by the vapor. The action is direct upon surface tissues, the cutaneous and particularly the respiratory membranes, since it is only with these that the irritant comes into direct contact. The severity of the effects is greatest upon those surfaces which are most easily penetrated—usually because of their being moist. Therefore, the epithelium and the mucous membrane of the respiratory passages and the conjunctiva are the seats of primary election.

Chemical Irritation and Vital Reaction.—The initial reactions are chemical or physical and can be reproduced for the most part *in vitro* by the action of the irritants upon protein. But these effects are scarcely visible. What we see and what the patient suffers from are the vital reactions which are set up by the irritation. The effects of all the irritants upon any part of the respiratory tract upon which they act at all are essentially of the same character, differing only in degree. Obviously, therefore, the consequent inflammation and edema are physiological reactions, not merely direct chemical effects. When hydrochloric acid acts on zinc, we see a solution of the metal with evolution of hydrogen gas. When hydrochloric acid acts upon a living tissue, the comparable direct effect is almost or even entirely

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invisible. Soon, however, the disturbed mechanism of the affected tissues manifests itself physiologically. If the tissue were already dead, concentration of the chemical, even far above the toxic minimum, would induce no visible effect. In other words, the effect of irritant gases, except in cases of most exceptional intensity, is not simple and direct corrosion. The irritant gases act in such extreme dilution that gross chemical corrosion is not usually involved; if involved at all, it causes almost instant death.

Determination of Locus of Action.—The differences in symptomatology and pathology which occur as the result of poisoning by different types of irritant gases are chiefly dependent upon the locus of action. For example, ammonia produces intense congestion of the upper respiratory passages and immediate death from laryngeal spasm or edema; on the other hand, phosgene and nitrogen peroxide cause little irritation of the upper respiratory tract but induce pneumonia or lung edema through their action upon the lung alveoli; chlorine in its action is intermediary between ammonia on the one hand and phosgene and nitrogen peroxide on the other. Such distinctions in the action of irritant gases are not due, in the main, to dissimilarity in their protoplasmic action but, as these illustrations show, are the results of the differences in the locality in the respiratory tract upon which they act.

The fact that such selective action by the various irritants is due to their physical, rather than their chemical, properties is particularly true of solubility. Thus a gas which is very soluble in water and is readily diffusible in its solution is taken out of the inspired air by contact with the first moist tissue which it reaches. As a consequence the upper respiratory passages bear the brunt of the action, while the lungs are relatively little affected, since the concentration of the irritant which reaches them is greatly reduced. In case the gas has a very low solubility in water, or requires further hydrolytic decomposition to liberate its irritant principle, the upper respiratory passages suffer relatively little, for little is absorbed, and the main damage is done deep in the lungs.

The following simple experiment illustrates how this underlying principle determines the selective action of irritant gases upon the various parts of the respiratory tract. Each of the various irritant gases in turn is diluted with a large volume of air in a suitable vessel and is then passed slowly through a long glass tube containing a strip of filter paper moistened with water and extending the entire length of the tube. The amount of each gas which is absorbed in the water held by the paper in different parts of the tube is chiefly determined by the solubility of the particular gas. The nearer end is saturated first. For a very soluble gas the amount absorbed in that location is large and the amount further on comparatively small. On the other hand, the amount of an insoluble gas so absorbed is small, and the concentration which passes out of the effluent end of the tube represents the concentration which might reach the lungs. In this artificial system the continued passage of the gas results in an increase in the concentration of the dissolved substance in the fluid, until the further absorption of the gas from the air is inhibited and the effluent air finally approaches the affluent concentration of gas. This aspect of the scheme, with a few exceptions, does not occur in the living body. Equilibrium is not reached between the irritant in the air and the

fluid of the tissues. The irritant cannot exist as the free substance while in contact with the tissues, but is combined with or altered by them as an incident of the action and of the vital reactions induced. In the case of very soluble irritants the lungs are thus protected and the action upon the upper respiratory passage is intensified.

The reduction in the concentration of an irritant gas effected by absorption in the fluids of the upper respiratory tract has an additional importance because of the altogether disproportionate effects upon the lungs of high and low concentrations in the air inhaled. In the case of the volatile irritants, as is well recognized in the case of the liquid and solid cutaneous irritants, the severity of the action does not vary in proportion to the amount and duration of the application; but a high concentration, for even a short time, has an intense effect. Consequently, any reduction in the concentration of the irritant during its passage through the upper respiratory passages results in a disproportionately large sparing action upon the tissues of the lungs.

Protective Reflexes.—The immediate physiological response to the inhalation of an irritant gas is more marked in the upper than in the lower portions of the respiratory tract. The nasal passages and the larynx readily become acutely painful, while little immediate discomfort attends the action of irritants upon the deeper bronchi or upon the lungs themselves. Furthermore, the irritation of the upper respiratory tract elicits a series of reflexes which tend to prevent the penetration of the irritant to the deeper and more delicate respiratory structures.

The protective respiratory reflexes consist in coughing, constriction of the larynx and bronchi, closure of the glottis, and inhibition of respiration. Coughing is initiated by even slight irritation of the larynx and consists of a series of expiratory blasts which tend to expel the stimulating material. Coughing obviously does not prevent the passage of irritant gases, but it warns of the presence of these substances. When higher concentrations of irritants act upon the larynx, the superior laryngeal nerve is stimulated, and respiration is inhibited with the chest in the position of expiration. The breathing is almost equally disturbed by stimulation of the sensory fibers of the trigeminal nerve in the nasal passage. With severe irritation, the glottis is reflexly closed by constriction of the adductor muscles, and the bronchial musculature is constricted so that the passages to the lungs are partially closed. The inhibition of respiration is temporary and is broken through by the increasing excitement of the respiratory center, owing to the lack of ventilation and the increasing venosity of the blood. The spasm of the glottis may persist so long that symptoms of acute asphyxia are induced. The constriction of the bronchi, particularly of the smaller tubes, may be sufficient to prevent the entrance of the gas into portions of the lungs even under the most acute conditions. As a result of this bronchoconstriction areas of atelectasis and emphysema may occur, a matter to be discussed further in a later section.

The coughing reflex as a warning of the presence of an irritant in the respired air is subject to considerable individual variations. Persons with pharyngeal passages rendered sensitive by the use of tobacco or from infection cough more readily than do normal persons. Those with chronic mild inflammatory or catarrhal conditions may have a decreased susceptibility and cough less readily.

Relative Seriousness of Injury to Different Levels of the Respiratory Tract.—These physiological efforts to protect the different parts of the respiratory tract are of extreme importance. The delicacy of the respiratory membranes, their susceptibility to injury, and the seriousness of the damage which results increase in passing from the upper to the lower respiratory tract. The nose and pharynx may be stripped raw and yet suffer little permanent damage. The larynx and bronchi suffer to a greater extent, and general systemic effects also develop just as in the case of acute laryngitis and bronchitis from any cause. The lungs when directly acted upon by an irritant are seriously damaged and give rise to acute response in edema or pneumonia, with prostration and failing heart and circulation, the outcome of which may be fatal.

In the pharynx, trachea, and bronchi the first degree of inflammation consists of arterial and capillary hyperemia, a primary active vascular response, which is later passive or secondary. The most superficial vessels are dilated first, and progressively those of the deeper tissues become involved, partly directly and partly by reflex.

The irritation of the mucous membrane stimulates its innumerable minute glands to produce a profuse flow of mucus. In very moderate exposure to gases which affect the upper respiratory passages, the danger may not extend beyond rubefaction. In this case the symptoms are those of general mild pharyngitis and laryngitis. Resolution takes place by return of the vessels to normal without leaving any lesion. If the action of the irritant is stronger than rubefaction, definite necrosis of the tissues of the upper respiratory passages and bronchi develops. This appears first as a loss of normal gloss and translucency with some edematous swelling. Plasma is exuded and this coagulates upon the surface and is frequently streaked with extravasated blood. The tenacious layer thus formed may appear as a membrane. In severe cases the mucosa may be lifted from the submucosa by fluid. This tissue sloughs off, leaving raw and oozing surfaces covered with mucopurulent material.

If death does not occur as an immediate result of lung edema, the usual symptoms of severe membranous bronchitis and tracheitis may persist for some days. The mucous membrane then begins to regenerate from patches of relatively uninjured epithelium where folds in the mucosa have protected it. In the larger bronchi the repair is usually effected with little permanent cicatrization. The smaller bronchial tubes may show some thickening of the walls as a permanent result. Before the regeneration of the mucosa can occur, however, infection of the bronchi almost always supervenes, since the normal barrier to bacterial invasion is removed.

In severe cases of inflammation of the upper respiratory tract the larynx may present very marked edematous swelling. As a result of this, the opening into the trachea may be occluded and death may result from acute asphyxia. This is the common cause of rapid fatality during or very soon after severe exposure to irritant gases which largely affect the upper tract.

In case death does not result immediately from laryngeal edema or functional spasm of the glottis, lung edema may develop. The condition reaches its height in from twelve to twenty-four hours. If death does not occur, it tends to regress within forty-eight hours. This edema is the result of the damage to the epithelium of the finer air sacks

in the lungs, both atria and alveoli. It consists in an accumulation of fluid interstitially. The lymphatics are engorged. Fluid also escapes from the capillaries over the surface upon which the irritant has acted. A portion of this fluid may coagulate and fill the alveolar space with fibrin, thus seriously interfering with the respiratory exchange of oxygen and carbon dioxide between the air and the blood. It also obstructs the flow of blood through the lungs and thus places a strain upon the right side of the heart. The edema occasioned by irritant gases differs from that of non-irritant origin in that, while the latter usually shows a marked preference for the pendant portion of the distribution after gassing, the former is not greatly affected by gravity or the posture of the subject. Not all parts of the lungs, however, are affected equally by the edema. The action of the irritant upon the smaller bronchial tubes causes many of them to constrict so that the portions of the lungs to which they lead escape the action of the gas. Owing to this bronchoconstriction as well as to plugs of sloughed mucosa and fibrin, areas of atelectasis and emphysema may occur in the edematous lung.

Irritation of the lungs does not give rise to severe pain, as does that of the upper passage. The principal symptoms are those of asphyxia. This asphyxia, however, is of a peculiar character since its early stages are not associated with marked air hunger. The patient may present only an ashy gray color, no dyspnea, and yet be in danger of death, especially on the slightest exertion. In the later stages blue cyanosis and intense air hunger may be added to the clinical picture. The state of gray cyanosis without marked dyspnea is due to anoxemia unattended by increased carbon dioxide in the blood. In this respect the anoxemia of early pulmonary edema is similar to that of mountain sickness. In the later stage of the edema there is interference with both the carbon dioxide and the oxygen exchange, and the classical symptoms of asphyxia develop.

The peculiar characteristics of early pulmonary edema are due to the unequal ventilation of the blood with respect to carbon dioxide and oxygen. Carbon dioxide is about twenty-five times as soluble as oxygen in the plasma which covers the surface of the alveoli. At first, therefore, the exchange of oxygen is hindered to a greater degree than is that of carbon dioxide, and the oxygen of the blood is decreased without any appreciable rise of carbon dioxide. As oxygen deficiency is a relatively weak stimulant to respiration, the signs of asphyxia are not marked. With the progress of the edematous conditions some of the alveoli become filled with frothy fluid, and the terminal bronchioles become plugged. Such areas then take little part in the gas exchange of the lungs, and the air occluded within comes to have the same gas pressure as the venous blood. At the same time other areas which are less involved in the edema are hyperaërated, and the carbon dioxide is reduced below the normal level. Hyperaëration cannot, however, raise the oxygen content of the blood passing through these parts of the lungs above the amount which the hemoglobin normally holds. The characteristics of the oxygen-hemoglobin dissociation permit no more. Under these conditions the blood which reaches the left side of the heart is a mixture, one portion of which has the same content of gases as the venous blood, while the other approaches the normal arterial blood in its content of oxygen but is lower than normal in carbon dioxide.

The blood which enters into the arteries is thus low in oxygen but, during the early stages, not far from normal in respect to carbon dioxide.

As the severity of the edema increases, the carbon dioxide as well as the oxygen is interfered with to an increasing degree, and the carbon dioxide content of the arterial blood rises, with a corresponding augmentation of the respiratory exertion. In asphyxia the more marked symptoms depend upon an excess of carbon dioxide in the arterial blood, but the more serious damage results from the deficiency of oxygen. The asphyxia of lung edema arising from irritant gases, therefore, is more dangerous than the superficial signs would indicate.

As already stated, severe lung edema usually terminates fatally, but in nonfatal cases the alleviation of the acute symptoms of the gassing usually occurs within forty-eight or, at most, seventy-two hours, and is followed by symptoms of acute infection of the respiratory tract. No medicinal measures are effective in relieving pulmonary edema. The inhalation of oxygen tends to relieve to some extent the anoxemia and cyanosis and should always be employed, if possible, although it has no markedly beneficial influence upon the other acute symptoms or upon the progress of the disease.

The pneumonia following gassing may be either lobar or bronchial, or of a mixed type. The organisms occasioning this infection are usually those which normally inhabit the upper respiratory tract. The mortality is high, death occurring in from four days to two weeks. The symptoms are those commonly found in similar infections of non-irritant initiation. Even an exposure insufficient to induce the acute symptoms of lung irritation may lead to the development of pneumonia, and under industrial conditions the infections thus induced constitute a greater cause of death than primary pulmonary edema. Many observers feel that irritant gas or vapor even in extreme dilution is to be regarded as predisposing to the development of pneumonia. The only exception to this statement is afforded by chlorine which, in low concentrations, seems to exert a bactericidal action without appreciable irritation.

On the other hand, there is considerable uncertainty as to the rôle of irritant gases as a predisposing factor in the development of pulmonary tuberculosis. This disease cannot be said to arise as a direct sequel of irritation of the lungs as is the case with pneumonia. The statistics of the subsequent health of soldiers gassed during the war indicate that when the lungs have once healed they are not appreciably more liable to tuberculosis than would otherwise have been the case. On the other hand, when the subject has suffered a period of decreased vitality or ill health as a consequence of the action of irritant gases upon the respiratory tract or as a result of the subsequent acute infection, then tuberculosis may develop as a recurrence of a previously existing lesion just as is often the case following decreased vitality from any other cause. It often happens that the subject has had no knowledge of this preexistent but dormant infection; indeed, it may not have been elicited even by physical examination. In considering tuberculosis, however, it is necessary to assume that every normal healthy person carries a dormant infection and that the disease is liable to become clinically evident whenever the resistance of the body is lowered sufficiently. Thus gassing may fairly be said to be, in the ordinary use of the words, the cause of a tubercu-

losis progressing steadily from the occurrence of poisoning, but not of a tuberculosis developing at some time subsequent to virtually complete recovery from the gassing itself. The crux of the question in any particular case is whether or not the gassing undermines the subject's general health.

The Chronic Effects.—After a severe irritation of the lower respiratory tract, the damage may be sufficient to result in a chronic inflammatory condition and to produce a protracted period of ill health. The most characteristic features are chronic bronchitis, cicatrization of the lungs, and obliteration of a portion of the deeper structure of the lungs, sometimes with abscess formation. In certain cases physical examination may give little evidence of persistent pulmonary change, and the subject at rest appears normal but is incapable of anything more than the most moderate exertion. This condition may persist for a long time. In view of the fact that direct pharyngeal inspection and X-ray examination fail to reveal evidence to explain the disability, malingering may be suspected unjustly.

The bacterial infection following acute irritation may leave focal infections pocketed in necrotic areas of the lung or bronchiolar tissues. Such persistent infections are the cause of long continued ill health with symptoms like those of any focal infection.

Prolonged exposure to sublethal concentrations may induce chronic poisoning consisting in a moderate inflammation of the upper respiratory tract associated with a sharp cough. If the exposure is a more or less regular part of the man's working conditions the inflammation passes into a catarrhal state and the coughing becomes a less marked feature. The worker then appears to have acquired a partial tolerance to the gas. No true tolerance exists, however; the appearance arises from the fact that the protective reflexes are less active because of the protection afforded the mucous membranes of the upper respiratory tract by the tenacious mucus with which they are coated. The catarrh does not, however, afford any protection to the tissues of the deeper respiratory tract. It rather exposes them the more to the action of the gas, because of the partial abolition of the respiratory reflexes. In addition, it exerts the usual detrimental influence upon the general health, causing loss in weight, increased susceptibility to acute infection, and greater liability to the development of tuberculosis.

The Absorption of Irritant Gases or their Neutralization Products through the Lungs

The action of most of the irritant gases upon the respiratory tract results in their destruction or neutralization, and for this reason they are not absorbed into the body in their original form. The products of destruction or neutralization do not as a rule, after absorption, cause any systemic poisoning. There are, however, a few exceptions to this rule, notably hydrogen sulphide and nitrogen peroxide. The sulphide is absorbed and neutralized in the respiratory tract to sodium sulphide, and during the process irritation is caused. But a profound systemic poisoning is produced by the absorption of this alkaline sulphide into the blood stream. In somewhat the same way, although in a less degree, sodium nitrite is formed as a result of the inhalation of nitrogen peroxide, and may induce more or less acute symptoms of nitrite poisoning, which are usually concealed by the much more acute pulmonary irri-

TABLE 1.—**RELATION BETWEEN THE PHYSICAL PROPERTIES OF IRRITANTS AND THEIR SITE OF ACTION IN THE RESPIRATORY TRACT AND SUBSEQUENT SYMPTOMATOLOGY**

Irritant	Approximate Solubility in Water by Volume at 40° C.[1]	Site of Main Action upon Respiratory Tract	Nature of Local Action	Concentration Dangerous to Breathe for 1 Hour[2] Parts per Million of Air	Symptomatology
Ammonia gas	444 (extrapolated)	Upper respiratory tract	Alkaline caustic	2,000	Elicits immediate and violent respiratory reflexes; coughing and arrest of respiration.
Hydrochloric acid gas	385	Upper respiratory tract	Acid action. Neutralizes alkali of tissues and alters the reaction	1,500	Death from edema or spasm of larynx. Upper respiratory tract inflamed.
Formaldehyde	Very soluble	Upper respiratory tract	Combines with proteins and alters them	— —	
Sulphuric acid	Encountered as droplets	Upper respiratory tract	Acid action	— —	
Sulphur dioxide	18.7	Upper respiratory tract and bronchi	Acid and oxidizing action	400	Elicits respiratory reflexes. Rarely causes death from edema of the larynx. Trachea and bronchi inflamed. Lung edema rare.
Bromine	9.4	Both upper and lower respiratory tract	Oxidizing action	60	Elicits respiratory reflexes. Inflammation of entire respiratory tract. Edema of lung after severe exposure.
Chlorine	1.4	Both upper and lower respiratory tract	Oxidizing action	40	
Phosgene	Decomposes	Lower respiratory tract	Liberated HCl has acid action	25	Does not elicit marked respiratory reflexes. May be fatal in concentrations which cause no reflexes at all. Upper respiratory tract inflamed only after very severe exposure. Usually no immediate symptoms. Delayed death from lung edema.
Nitrogen peroxide	Decomposes	Lower respiratory tract	Liberated HNO_3 and HNO_2 have acid and oxidizing action	117[3]	

[1] Landolt-Börnstein: Physikalisch-Chemische Tabellen. Berlin, Julius Springer, 1905, p. 599.
[2] Kobert, R.: Kompendium der praktischen Toxikologie. Stuttgart, F. Enke, 1912, p. 45.
[3] The toxicity of phosgene is greater than that of nitrogen peroxide for the reason that a portion of the peroxide is decomposed into the relatively weak nitrous acid.

tation.

A few substances, generally classed as irritants, are absorbed unchanged from the respiratory tract. These are chiefly

organic substances such as alcohols, ethers, aldehydes, volatile petroleum, coal tar products, etc., which are not altered or destroyed by contact with living tissue. Their systemic effects are as a rule greater than their action as pulmonary irritants.

The local action of these substances differs from that of the more common irritants in two respects: (1) The mucous secretion which results from their action upon the respiratory passages does not serve to form a protective coating against their action; the secretion neither neutralizes nor alters these substances, but rapidly becomes saturated with the gas at the tension inhaled. (2) The greater part of the irritant action occurs in the upper respiratory passages, bronchi, and bronchioles, while the lung alveoli and atria are relatively little affected. Such amounts of the gas as reach the lungs themselves are absorbed unchanged. This location of action is quite exceptional, for the solubility of these substances is usually quite low. The sparing of the deeper portion of the lungs is the result of the active absorption into the blood, which keeps the concentration of the irritant in the alveoli constantly at a low level.

Application of Principles Presented

Table 1 contains the data here generalized, as applied to the more common irritants. It is believed that with the general principles above formulated and the particulars for any gas, especially its solubility and general chemical character, a sufficiently complete definition of the physiological action is afforded. A prolonged, complicated and detached description of each particular gas is thus obviated.

The concentrations which cause dangerous symptoms after an inhalation of one hour are also given in the table. It is noteworthy that the less soluble gases are progressively more toxic, a fact which is in accord with the principles presented.

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